

**Geophysical Investigations of Earthquake-Induced Liquefaction  
at Cultural Sites in the New Madrid Seismic Zone**

**Annual Project Summary**

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**TOWARDS A PALEOEARTHQUAKE CHRONOLOGY FOR  
THE NEW MADRID SEISMIC ZONE:**

**Annual Project Summary**

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## **Investigations Undertaken**

Investigations conducted under these project awards have focused on the search for evidence of liquefaction caused by prehistoric earthquakes at archeological sites (Archaic through Mississippian cultural periods) in the NMSZ. This work has been carried out as a collaboration between Dr. Martitia Tuttle of M. Tuttle & Associates, Dr. Lorraine Wolf and students of Auburn University, and Dr. Robert Lafferty of Mid-Continental Research Associates and represents a continuation of past collaborative efforts (Barnes, 2000; Barnes et al., 1999; Collier, 1998; Collier et al., 1997; Tuttle, 1999; Tuttle et al., 1999; Wolf, 1999; Wolf et al., 1998). This study is designed to improve age constraints of liquefaction events prior to A.D. 800 and to expand regionally the database of historic and paleoliquefaction features ([Figure 1](#)); see Tuttle, 1999 or 2001, for comprehensive summary). In addition, the research is aimed at collecting data on the sediment characteristics at sites that have experienced liquefaction in an effort to understand better the geologic factors that contribute to liquefaction susceptibility (e.g., thickness and composition of the topstratum or confining unit, depth to the liquefiable layer, site stratigraphy, etc.). Thus far, the first of the following four (4) project objectives has been achieved:

- 1) reconnaissance surveys to determine the presence of sand blows at cultural sites in the NMSZ and the approximate age of the liquefaction features;
- 2) surface geophysical surveys at selected sites to identify buried liquefaction and cultural features prior to site excavation and to gain information on the stratigraphy and sediment properties of the site;
- 3) trench excavations to expose spatial relationships between liquefaction and cultural features and to gain insight into the age of the liquefaction event; and
- 4) depending on the results of (3), detailed logging of trench walls and collection of samples for sediment analyses and age dating.

## **Results to Date**

The PIs, Tuttle and Wolf, and Sharon Browning, an Auburn University graduate student, in conjunction with Dr. R. Lafferty (archeologist) conducted reconnaissance at seven (7) sites during the first project year ([Figure 1](#)). Each site was evaluated for the potential of finding liquefaction features in association with cultural horizons and features and for its suitability for geophysical surface surveying. In addition, Tuttle and Lafferty evaluated six (6) other sites for future paleoseismic investigations. Details of the findings at each of the sites are outlined below.

**1. Archway (3MS620):** A large sand blow and associated sand dikes exposed in a drainage ditch were the target of a previous paleoseismic investigation (Tuttle et al., 2000) at this archeological site, located northeast of Blytheville, Arkansas. In the previous study, a detailed log was prepared, and artifacts and organic samples were collected for dating. At least three fining-upward sequences constitute the sand blow, possibly corresponding to three episodes of liquefaction at the site. The sand blow overlies a paleosol containing a few Native American artifacts of the Woodland cultural period, including a large Withers fabric-marked potsherd diagnostic of the terminal Early Woodland (Ca 300 B.C. to A.D. 300). The position of the Woodland artifacts below the sand blow suggests that it is prehistoric in age. However, radiometric dating yields calibrated dates of A.D. 1670-1960 for a wood sample collected below the sand blow, and A.D. 1680-1960 for a charcoal sample collected within the top of the sand blow. Given its undecomposed nature, the wood in the clay below the sand blow might have recently grown into the deposit from the bottom of the ditch. Although the sand blow has been tentatively attributed to the 1811-1812 earthquakes due to the results of radiometric dating, additional study of the relationship of the sand blow to the cultural horizon is warranted. As part of our current project, we revisited the site and examined an area where artifacts are abundant on the ground surface and where a Woodland pot was recovered from a zone below the plow zone and above a sandy layer (M. Haynes, pers. comm., 2000). This area was not far from the ditch where the previously studied liquefaction features had been exposed. If this sandy layer is related to the sand blow exposed in the ditch, the sand blow would be prehistoric in age and would have formed during the Woodland cultural period. We will conduct geophysical surveys at this site in November 2001 to identify a trench location that will best reveal the relationships of the sand layer to the exposed sand blow and to Woodland cultural horizons and features. Once the excavation is made, we will determine whether detailed logging of the site and sample collection and analysis is warranted, and if so, proceed with the logging at that time.

**2. Bradley Ridge (3CT7):** This site is located north-northeast of Marion, Arkansas, and was partly selected for review because of its proximity to Memphis, Tennessee. This is a Mississippian mound site and may have been visited by Spanish explorer de Soto in 1541 (R. Lafferty, pers. comm., 2000). During reconnaissance, we found the mound and surveyed the nearby fields for sandy patches and poor crop growth typical of sand blows in the New Madrid region. For the most part, however, poor crop growth was related to wet soil conditions at the time. Sandy soils were observed south of the mound and a test pit was excavated. Below the plow zone, a subsurface fine sandy deposit exhibited cross-bedding and contained no clasts. It did not exhibit characteristics of sand blows and was interpreted as a fluvial deposit. Based on our findings, no further investigations are planned for this site.

**3. Dillahunt (3MS619):** Dillahunt is located northeast of the Archway site, and like Archway, was probably occupied during the Woodland cultural period. This site was drawn to our attention by M. Haynes, who had observed a sandy patch that adversely affects crop growth. During reconnaissance, we located the sandy patch and found sand- and grog-tempered potsherds on the surface. We have selected this site for geophysical surveying and excavation during the November 2001 field trip to determine whether the sandy patch is a sand blow, and if so, what its relationship is to the Woodland occupation horizon at Dillahunt. If liquefaction features are found during trenching, they will be logged and archeological test units will be excavated in associated occupation horizons.

**4. Hart (3RA0406):** Hart is a multi-component archeological site, including an Archaic camp, Woodland hamlet, and Mississippian homestead (Julie Morrow, pers. comm., 2000). It is located northeast of Pocahontas, Arkansas, in the Western Lowlands. The site occurs within a small area of light-colored elliptical patches observed on aerial photographs and brought to the attention of Tuttle by Jim Vaughn. The site occurs within 3 km of sand dikes exposed in cutbanks of the Current River (Tuttle, 1999). The hope was that the Hart site would provide a good opportunity to date sand blows in this part of the Western Lowlands. During reconnaissance, however, the site was found to have been leveled, with up to 1.5 m of soil removed in places. Much of the land in the area has been or is currently being leveled in order to control soil moisture through irrigation and thus improve crop yields. No further investigations are planned for this site.

**5. Henderson Mound (23NM):** Henderson Mound is located north-northeast of New Madrid, Missouri, and close to the north-northeastern trend of New Madrid seismicity. On 1950 aerial photographs, it appears that there are large sandy patches on and around Henderson Mound. During reconnaissance, however, we found no artifacts on Henderson Mound and we found the mound itself to be very sandy. Late Wisconsin valley train deposits and associated sand dunes and eolian deposits have been mapped in the area (Saucier, 1994). Many of the large sandy patches observed on aerial photographs are probably sand dunes rather than sand blows. No further investigations are planned for this site.

**6. Langdon (23DU1):** This is a Native American mound site located near Hornersville, Missouri, and artifacts of both the Mississippian and Woodland cultures are known to be present (R. Lafferty, pers. comm., 2000). On aerial photographs of the site, light-colored patches suggestive of sand blows occur in the vicinity of the mounds. The site lies in braided stream deposits west of the Mississippi River, in an area where few prehistoric liquefaction features have been identified. During reconnaissance, five sand blows were observed at the surface and confirmed in test pits. Most of the sand blows appeared to be historic in age based on their degree of soil development; however, one of the sand blows may be prehistoric in age. This site will not be studied during our November 2001 trip but probably will be investigated in 2002.

**7. Mathews (23NM3):** . The Mathews site, which includes both Woodland (500 B.C. to A.D. 1000) and Mississippian (A.D. 800 to A.D. 1670) archeological components (R. Lafferty, pers. comm., 2000), is located on Sikeston Ridge in an area where there are few data regarding liquefaction events. During reconnaissance, we found that much of the site had been severely graded. Due to the degree of disturbance, detailed investigations are not planned for this site. However, further review of archeological reports may yield additional information about liquefaction features.

**8. Obion River 216:** This site was not among the targeted archeological sites listed in our original proposals; however, during reconnaissance, we investigated a large sand dike discovered by Tuttle that had been exposed along the bank of the Obion River. The dike, approximately one meter wide, feeds into a partially reworked sand blow, which is also exposed along the cutbank. The dike trends northeast, and units on the east side of the dike appear to be downdropped. The trend of the dike, according to Tuttle, is similar to the trend of mapped faults in the area, suggesting that this outcrop may be a surface expression of more widespread faulting. The exposure was logged and *in situ* tree stumps yielded dates that suggest the liquefaction event occurred after A.D. 1300. To investigate the possibility of whether the offset of strata along the dike is related to faulting at depth, we have identified a transect for a seismic reflection survey that should cross the projected position of the dike on the floodplain. We plan to do the reflection survey during the November trip, once crops are removed from the adjacent field.

**9. Rose Mound (3CS27):** The Rose Mound includes both Woodland and Mississippian archeological components (R. Lafferty, pers. comm., 2000). The site is located along the St. Francis River west of Memphis and about 20 km south of our southernmost liquefaction site. Although we located the site, we were not able to contact the owner and so did not conduct a survey of the site. We will continue to try to gain access and hope to conduct reconnaissance of the site in 2002.

**10. Schugtown (3GE2):** Schugtown is a Mississippian archeological site, including several mounds (Julie Morrow, pers. comm., 2000). It is located southeast of Paragould, Arkansas, near the St. Francis River. Sand blows occur in nearby fields and along Eightmile ditch. Sand blows documented along Eightmile Ditch are historic in age. The hope was to find prehistoric sand blows at the archeological site that we would be able to date and to compare to historic sand blows in the area. During reconnaissance, however, sand blows in the vicinity of the archeological site were found to be historic in age based on their soil characteristics. Although artifacts were abundant at the site, few artifacts were found on the sand blows. No further investigations are planned for this site.

**11. Shelby (23MI68):** This is a Native American mound site southwest of Charleston, Missouri, in the vicinity of liquefaction induced by the 1895 Charleston earthquake of **M** 6.6. Artifacts of both the Mississippian and Woodland cultures are known to be present at the site (R. Lafferty, pers. comm., 2000). During reconnaissance, we located the site, which was characterized by a high density of potsherds and lithics on what appeared to be a natural topographic high. In a test pit, the soil at the site was found to be sandy but did not exhibit any of the characteristics of sand blows. Soils in the vicinity of the site were generally sandy and no possible sand blows were identified. Late Wisconsin valley train deposits and associated sand dunes have been mapped in the area (Saucier, 1994) and might account for the sandy soils at the site. Also examined were several potential study sites, located between the Shelby site and Bertrand to the north, that had been identified earlier by Tuttle. Aerial photographs taken in the 1950s show possible sand blows southwest of Bertrand. Sand blows in the area are not obvious on more recent aerial photos. Crops were on the fields at the time of our reconnaissance, making it difficult to locate the sand blows and assess their potential for further study. Further reconnaissance and investigation of historic reports may yield additional targets in this area.

**12. Towasahgy (23NM12):** This Native American archeological site is located south of Charleston, Missouri, and is preserved as a State Historic Site. Mississippian and Woodland artifacts are present across the site. During a prior archeological investigation, Saucier (1991) found two sand blows beneath Mound A. However, the ages of these liquefaction features are poorly constrained. The site is now protected by the state and hosts an interpretative exhibit on Native American mounds and occupation. We recently examined the site to see if it would be feasible to run geophysical surveys in the vicinity of the previous excavations and, depending on the findings, reopen old trenches or possibly excavate additional areas. The site is promising but will require special permitting to gain access due to the culturally sensitive nature of the site. We hope that the inclusion of non-invasive geophysical surveying to minimize impact to the site will assist us in obtaining the necessary permits. We will begin the process of applying for permits, with the hope of following up with geophysical and paleoseismic investigations next year.

**13. Walnut (3MS2):** Records indicate that this archeological site was excavated by the University of Alabama in 1931 (R. Lafferty, pers. comm., 2000). Approximately 500 Native American burials were investigated at that time, and reports note an abundance of sand encountered during the excavations. In a recent reconnaissance of the site, Tuttle and Lafferty examined two sand blows at the surface and, based on soil characteristics, estimated one to be historic and the other to be prehistoric in age. Mississippian features and artifacts, as well as Woodland artifacts, occur in the nearby riverbank. Given the potential for finding a buried prehistoric sand blow at this site in association with Native American horizons and features, as well as the opportunity to compare historic and prehistoric sand blows at the same site, we will proceed with the geophysical surveys in November 2001, providing that crops are removed from the site. Crops were very high at the time of the last trip, and no survey was feasible at that time.

### **Summary of Planned Work for Second Project Year**

Our next fieldwork is scheduled for November 2001. During that period the PIs, Tuttle and Wolf, and three Auburn University students plan to conduct geophysical surveys (magnetics, resistivity and electromagnetics) at the Archway, Dillahunt and Floodway sites. Tuttle and the Auburn group will be joined in the field by Robert Lafferty (archeologist, Mid-Continental Research Associates), and Marion Haynes (archeological assistant, State of Arkansas). Following the geophysical surveys, the Auburn group will assist Tuttle with excavations, and depending on the findings, log trenches at that time. Samples for radiocarbon dating and artifact analyses will be collected from the trenches and archeological test units. During this fieldtrip, we also plan to collect seismic reflection data at the Obion River site, and if time allows, electromagnetic data at that site as well. Once the geophysical data are acquired and excavations are completed, we will return to Auburn to process and interpret the data. Tuttle will complete final renditions of the trench logs, with assistance from Sharon Browning, during the second project year. These data will be interpreted in conjunction with results of the radiocarbon dating (Beta Analytic) and the artifact analyses (Lafferty) to determine the age of the liquefaction features and thus past earthquake sequences. Results will be incorporated into a larger database of documented liquefaction features and events for the New Madrid seismic zone and interpreted in terms of timing, source areas, magnitudes, and recurrence intervals of large New Madrid earthquakes.

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### **Non-technical Summary**

This project focuses on the search for evidence of soil liquefaction caused by earthquakes at archeological sites in the New Madrid seismic zone. The study seeks to improve age constraints of liquefaction events prior to A.D. 800 and to reduce uncertainties related to timing, source areas, magnitudes, and recurrence intervals of large New Madrid earthquakes. Reconnaissance was performed at thirteen (13) sites during the first project year. Four (4) sites were selected for detailed investigations in November 2001, and another three (3) for investigation in 2002. Geophysical surveys will be used to minimize disturbance of the cultural sites during trenching.

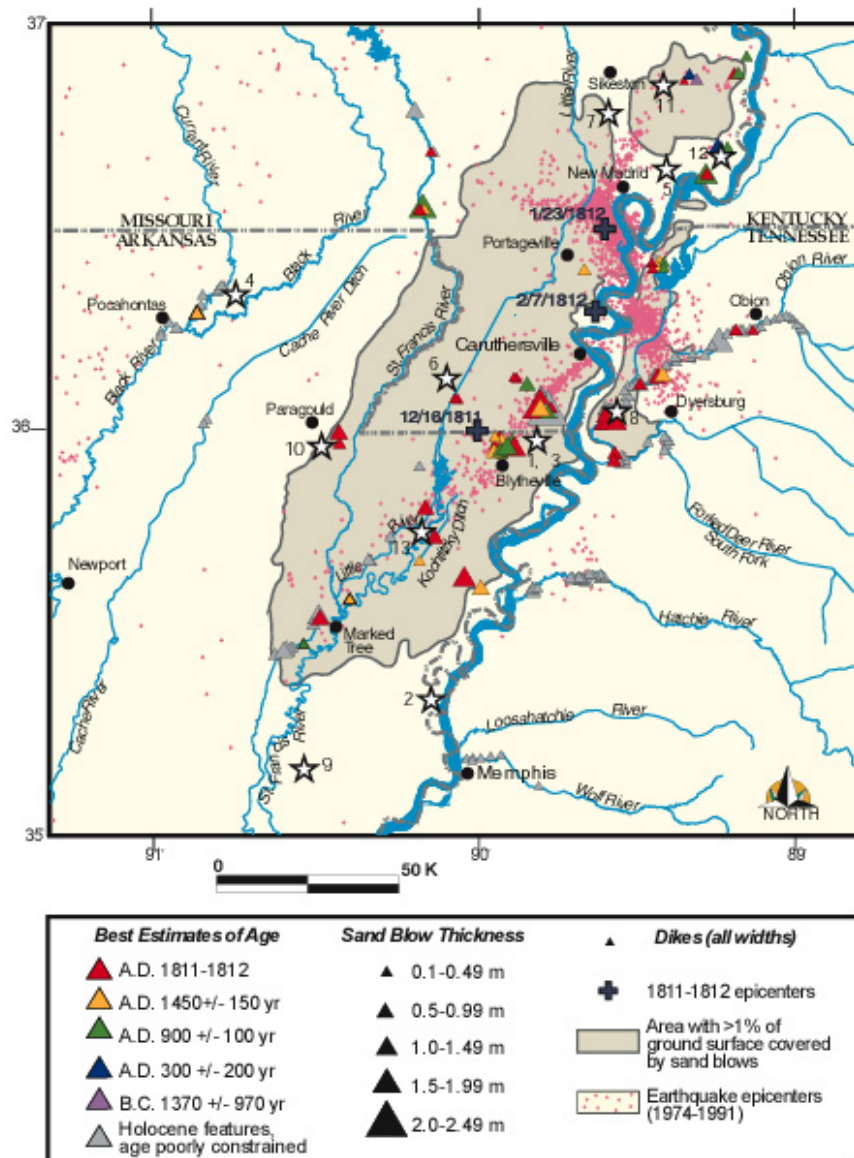


Figure 1. Map of New Madrid seismic zone and surrounding region. Results of previous paleoseismology studies shown with triangles, colored and scaled according to legend above. Study sites described in report are denoted by numbered white stars.